able that the present æcidium has no connection with our known Gymnosporangia, and that its other stages may very likely be traced to other Uredineæ which inhabit warmer regions near the Gulf of Mexico and the Atlantic. The resemblance of the galls in the two fungi is certainly curious.

The relation of Æc. Bermudianum to the Rœsteliæ already known in the United States is not very close. A differential diagnosis is hardly necessary, for the characters above will be recognized as sufficiently marked by those who study this group of plants. The species which in the microscopic characters of the spores and peridial cells comes nearest to the present species is *R. lacerata* Cooke, which grows on Cratægus in the Southern States. In the distortions produced, the absence of ridges on the peridial cell, and several other respects, the differences between the two are decided. It is to be hoped that observers in the field will gather more information about this curious fungus.

Insect relations of certain Asclepiads. I.

CHARLES ROBERTSON.

(WITH PLATE XII.)

ASCLEPIAS VERTICILLATA.—The gynostegium is very small, the anther wings measuring about one and two-fifths millimetres. It fastens the corpuscula almost exclusively upon the hairs of the legs of insects; and, in this respect, shows a strong contrast even with A. incarnata. While the corpuscula of the latter are sometimes found on the tips of the claws of the largest visitors, Bombus and Sphex, those of this plant are rarely found even on the claws of the smallest, Ceratina dupla, Halictus, and Cerceris compacta (?). Of ninety-two specimens bearing corpuscula, eighty-eight have them on hairs alone, and four on the hairs and claws. That is, one specimen in twenty-three has them on its claws, while about one in three of those bearing corpuscula of A. incarnata has them on its claws. As the wings increase in size in the three following species, corpuscula are attached more frequently to the claws and less often to the hairs. Eight specimens show pollinia on their tongues. There is quite a contrast between this species and A. incarnata, in respect to the formation of combinations of corpuscula. A. verticillata does not form them so readily; and, in

fact, does not need to, as it is better adapted to fix its corpuscula directly upon the insect. On account of the shortness of the hoods, the position of the corpuscula on the legs of insects depends on how much the length of the legs exceeds that of the slits. The feet of the smallest visitors reach below the angles of the wings, and corpuscula are found on their tarsi. Large insects, bumble-bees, have pollinia on hairs from the claws to the middle of the tibiæ. I have found no dead insects on the flowers.

Associated with a gynostegium of the character indicated above we find hoods which are very broad and shallow, being not much over half as deep as those of A. incarnata. They open considerably below the level of the style-table, and their tips are turned outward, (fig. 1.)

Compared with A. incarnata, this species shows a marked increase in insects of small size and short tongues, Halictus, Odynerus, Cerceris, Crabro, Pompilus, Priocnemis, Myzine, and fewer long tongues. If it had been observed to the same extent and under as favorable conditions, it would show many more species of Hymenoptera. As the hoods increase in depth from this through A. incarnata, Cornuti, and Sullivantii, long tongued bees increase in number of individuals, while the number of species of Hymenoptera decreases. The number of species of butterflies in the table is quite misleading. The most common were small ones, which seldom remove pollinia of any Asclepias, the large species being represented by only one or two individuals of each.

In color, accessibility of nectar, and, consequently, in the general character of its insect visitors, A. verticillata shows more resemblance to certain Umbelliferæ than to the other species referred to in this paper.

Observations were made in a patch about fifteen feet long and four feet wide, on ten days, between July 20 and August 21.

	Hymenop.	Butterflies.	Other Lepidop.	Diptera.	
With pollinia	31	4	...	4	39
Without pollinia	9	11	1	7	28
	40	15	1	11	67

ASCLEPIAS INCARNATA.—The small anther wings are adapted to fasten the corpuscula upon the legs of large insects from the claws to the middle of the tibiæ, and on the claws and tarsal hairs of the small ones; but they catch the hairs much more frequently. Of 153 specimens bearing corpuscula, 103 have them on the hairs alone, 42 have them on the hairs and claws, and 8 on the claws alone; or, 145 have pollinia on the hairs, and 50 have them on the claws. That is, about one-third of the specimens bearing pollinia have the corpuscula attached to their claws. These processes are not so easily caught, because they are so large. Corpuscula are sometimes found on the tongues also, as I have found in 29 out of 156 specimens, 3 of these bearing them on the tongues alone. Combinations of corpuscula are formed much more readily than in A. verticillata. Sometimes a dead insect is found on the flowers. This occurs only when all or most of the feet are entangled simultaneously, so as to render the insect absolutely helpless. I have found Pelopœus cementarius and a Colletes killed in this way. As the flowers become larger, in the next two species, insects are killed more frequently.

The hoods are comparatively broad and shallow, and their tips do not project beyond the anthers. The visitors are more miscellaneous than those of the other species we have to consider.

The most abundant insects observed by me on the flowers were bumble-bees, especially Bombus separatus, wasps (Sphex and Tachytes) and butterflies (Papilio and Danais). Notes were made in a patch covering two or three acres, on twenty-one days, between July 22 and August 21.

	Hymenoptera.	Butterflies.	Other Leidop.	Diptera.	Coleoptera.	Hemiptera.	
With pollinia.....	38	15	...	3	3	1	60
Without pollinia	5	5	1	4	3	1	19
	43	20	1	7	6	2	79

ASCLEPIAS CORNUTI.—The anthers are much larger than in the preceding, and, as a consequence, the corpuscula are fastened to the claws of insects more frequently. The tarsal hairs are not readily caught unless they are

long. However, corpuscula are found more frequently on the pulvilli and on the hairs near the claws than on the claws. Even when small and short-legged insects succeed in extracting pollinia and inserting them into the stigmatic chambers they have great difficulty in breaking the retinacula, and often lose their lives in consequence. Hive-bees are frequently killed when most of their feet are entangled. On June 24 I picked thirty dead hive-bees from the flowers.[1] I have also found five species of flies and four species of moths killed on the flowers.

The hoods, although hardly longer than the anthers, are comparatively broad and deep, favoring long-tongued bees, which are the most abundant visitors.

As butterflies have been found on the preceding plants, they would be expected to occur on A. Cornuti. H. Müller gives a list of thirty-one species of insects observed on the flowers in Europe.[2] No butterflies are mentioned, but three species of Lepidoptera of other families, on which pollinia were not found. In Illinois I caught seventeen species on the flowers, six of these showing pollinia.

Notes were made on twenty-two days, between June 21 and July 22.

	Hymenop.	Butterflies.	Other Lepidop.	Diptera.	Coleoptera.	Hemiptera.	
With pollinia.....	10	6	1	7	1	3	28
Without pollinia	7	11	5	8	4	1	36
	17	17	6	15	5	4	64

ASCLEPIAS SULLIVANTII.—The anther wings are large and strong, the slits being fully one millimetre longer than in A. Cornuti. At the angles, the wings diverge strongly[3] so as to catch the divergent claws; and this is the only Asclepiad I have observed which fastens its corpuscula upon the claws more frequently than upon the other processes. The few small insects which occur on the flowers rarely get their claws caught, and, when they do, rarely escape.

[1] W. H. Leggett found dead hive-bees on some Asclepias, probably Cornuti, but does not mention the species. See *Amer. Naturalist*, iii, 388.

[2] "Fertilization of Flowers," 399, 400; also, "Befruchtung der Blumen," 336, and "Weitere Beobachtungen," iii, 61.

[3] See BOTANICAL GAZETTE, xi, plate viii.

The great number of hive-bees killed on the flowers of this plant and of A. Cornuti, besides being a matter of curiosity, and, indeed, of economic importance, is interesting in the study of the insect relations of the different species. Dead hive-bees are found on the flowers of A. Sullivantii much more frequently than on A. Cornuti. From the flowers of a patch which bore fifty-two follicles, I picked 147 dead hive-bees, from which it seems that the flowers are better adapted to kill hive-bees than to produce fruit through their aid. On seventeen days between July 2 and 27, 1885, I visited a patch to collect the insect visitors, and picked 671 from the flowers. I have often found four, and, in one case, seven dead bees on a single umbel. The intervals between my visit were such that many bees must have escaped my counting by being blown off by the wind, carried away by insects, or by falling with the flowers.

Most of the bees observed on the plants were trying to escape from the flowers. Of those which escape, many leave some of their tarsi between the anther wings, and must often die in consequence. These broken tarsi interfere with the insertion of the pollinia, and stop the claws in their passage through the slits. Many bees which might escape are killed by rain, for I have observed a marked increase in the number of dead bees on days following showers. Many fall a prey to predaceous insects. I have seen them, while still alive, attacked by ants, spiders and Podisus spinosus. I believe the Podisus frequents the flowers to prey upon the insects thus entangled.

There are two ways in which the flowers may bring disaster to hive-bees. It is common to find corpuscula, with their pollinia, fixed to some part of the tongue, and these bodies may interfere with the insertion of the tongue into narrow nectaries. Then, the corpuscula cover the claws so that the feet slip, and pollination is sometimes facilitated in this way. If the bee escape from the flowers with its tarsi, its trouble is not over, for it may lose its life on account of the claws being blunted by the corpuscula.[4]

Besides hive-bees, species of Megachile, Halictus, Astata, Lucilia,[5] Trichius, Pamphila, and Scepsis were found dead on the flowers.

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[4] See R. Bickford, *Am. Naturalist*, ii, 665. J. Kirkpatrick says: "When the claws are thus fettered, the bee can not climb upon the combs nor collect honey, and is soon expelled from the hive and must die. The unfettered bees tumble them out with little ceremony." *Am. Nat.*, iii, 109.

[5] The Diptera mentioned in this paper were kindly determined for me by Dr. S. W. Williston.

The large obovate hoods project half their length beyond the anthers, which increases their depth, and makes small insects less likely to become entangled. The structure of the hoods and the great difficulty smaller insects have in effecting pollination convince me that bumble-bees have had most influence in modifying the flowers, and they are the most common visitors except hive-bees.

It is to be remembered that hive-bees do not belong to our fauna, so that an adaptation to these flowers was not to be expected. By their great abundance, their constant efforts to escape, with the fact that their dead bodies occupy the flowers and give forth a disagreeable odor, they have produced a well marked disturbance of the insect relations of this plant.

	Hymenop.	Butterflies.	Other Lepidop.	Diptera.	Coleoptera.	Hemiptera.	
With pollinia.....	6	4	...	...	...	...	10
Without pollinia.....	10	7	2	3	1	1	24
	16	11	2	3	1	1	34

ASCLEPIAS TUBEROSA.—The anther wings are very delicate, as in A. verticillata, and are adapted to catch the tarsal hairs. Of many specimens bearing pollinia, two small bees, Cœlioxys and Augochlora, are the only ones with corpuscula on their claws.

The hoods are long and narrow, and their tips project far beyond the anthers, so that the nectar is only readily accessible to long and thin tongues.

The long tips also hold the bodies of insects so far above the angles of the wings, that only those with long legs easily remove the pollinia. The bright orange-red color of the flowers and the structure of the hoods suggest adaptation to butterflies, and the small anther wings seem to be especially suited to them. The claws of these insects are rather straight, and, when not in use, are held close together and directed in line with the leg; so that they do not often enter the slits. Whenever I have compared them, it has seemed that butterflies have corpuscula on their claws less frequently than do Hymenoptera. Of fifty-three specimens bearing Asclepias pollinia, only eight have them on their claws.

Notes were made on a few scattered plants on eighteen days between June 23 and August 17. This is the only species on which no bumble-bee was seen. By far the most abundant visitors are the butterflies.

	Hymenop.	Butterflies.	Other Lepidop.	Diptera.	
With pollinia	6	7	1	1	15
Without pollinia	3	4	...	...	7
	9	11	1	1	22

ASCLEPIAS PURPURASCENS.—The anther wings catch the hairs of the tarsi in all of the cases observed.

The hoods of the reddish purple flowers are long and narrow, their tips being much longer than the anthers (fig. 2). In the back of the hood is a process which projects inward to meet the broad horn, and thus completes the partition between the very narrow honey receptacles.

In my neighborhood A. purpurascens blooms first, when bumble-bee workers and Sphegidæ are least abundant, and shows a greater preponderance of butterflies than in A. tuberosa.

I watched a few plants on seven days between June 2 and 19.

	Hymenop.	Butterflies.	Diptera.	Hemiptera.	
With pollinia	1	5	1	1	8
Without pollinia	5	11	...	...	16
	6	16	1	1	24

ASCLEPIAS IN GENERAL.—The hoods are broad so that the intervals between them are narrow. In order that the legs of insects may be readily caught between them, they project strongly throughout and are open at the summit.

The open mouths are also of advantage in making the flowers more conspicuous, but are to some extent a disadvantage, since they make the nectar more accessible to many insects which are useless. The horn partly offsets this disadvantage. But for its presence small insects could crawl bodily into the hoods of the larger flowers. The horn has also the effect of making the nectar more or less double, notably in A. purpurascens; and I have observed in A. Cornuti and Sullivantii that bumble-bees insert their tongues regularly on each side of it.

Since a small gynostegium can catch more processes on an insect's leg, and so can fasten more corpuscula directly upon the insect, the habit of forming combinations of corpuscula[6] is less important to flowers having it. I have found no combinations of corpuscula of A. tuberosa, and few small ones of verticillata. (1) One advantage of their formation, and a ready explanation of their frequency in certain species, as A. incarnata, is to be found in the fact that the broken retinacula are often more easily caught by the wings than the hairs. Often the hairs are so short that they do not easily enter the slits; but when a corpusculum comes to be fastened to one of them advantage is taken of the circumstance, and a large combination is attached to its retinacula. For example, a specimen of Apathus elatus has six corpuscula on its tongue, all in one combination, illustrating the fact that it is often easier for A. incarnata to fasten a combination to a hair that is once caught than to catch another of the same length. (2) Long combinations are sometimes guided by the hoods over the angles of the wings, when the leg bearing them is not so guided (A. incarnata). I have seen pollinia of A. Sullivantii near the end of a combination drawn into the stigmatic chamber when the foot of the bee did not reach down to the angle. (3) After a corpusculum is fastened to every available process the carrying capacity of the leg is still indefinitely increased. This is so important in the large flowered species that I do not believe they could have been developed until this habit had become fixed in the smaller flowers. On the pulvillus of a hive-bee's foot I found a combination of eighteen corpuscula of A. Cornuti. But for the broken retinacula, it would have required every foot to carry these corpuscula, and then no new ones could have found room for attachment.

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[6] For figures of these combinations, see Corry's paper, Trans. Linn. Soc., Ser. 2, Bot., Vol. II, pl. 25.

The frequent occurrence of these combinations spoils the theory that the corpuscula enter the stigmatic chamber. That view can neither explain how they are formed nor how they escape destruction.

While in ordinary flowers an insect may be a useful visitor if it can reach the nectar, in Asclepias many other conditions influence the insect relations. (1) Of visitors whose tongues are suited to the nectaries, many are useless, because they do not light upon the flowers (Sphingidæ, Ægeriadæ and Trochilus).[7] (2) Others because their legs are not long enough to extract pollinia. Megachile is common on A. tuberosa, but never, so far as observed, carries pollinia. (3) Others have legs long enough, but rest their feet so lightly on the flowers that they seldom effect pollination; e. g., Diptera and small butterflies. (4) Still others are not strong enough to free their claws from the slits and break the retinacula; in all, seventeen species were found to be killed on this account.

The table shows the number of species visiting the flowers, with the disposition of the corpuscula on them.[8]

	Hymenop.	Butterflies.	Other Lepidop.	Diptera.	Coleoptera.	Hemiptera.	
Corpuscula on hairs, claws and tongue.....	14	...	...	...	2	...	16
" " hairs and claws	8	7	...	...	...	1	16
" " hairs and tongue.....	5	1	...	3	...	...	9
" " hairs alone.....	26	15	1	7	2	3	54
" " claws alone.....	3	...	...	...	...	...	3
" " tongue alone	1	...	...	2	...	...	3
" none	13	12	6	13	5	...	49
	70	35	7	25	9	4	150

The most striking peculiarity of Hymenoptera is the frequent occurrence of pollinia on their tongues. Of twenty-eight species with pollinia in that situation, twenty are Hymenoptera. Bembex which resembles certain Syrphidæ[9] in

[7] The ruby-throated humming-bird visits A. incarnata, Sullivantii and purpurascens.
[8] In the table the pulvilli are included under "hairs."
[9] Packard, "Guide to Study of Insects," 161.

colors and manner of flight, also imitates them in resting lightly on the flowers and extracts pollinia less frequently than any wasp I have seen.

EXPLANATION OF PLATE XII.—Fig. 1, Gynostegium of *Asclepias verticillata* L., with one hood removed. Fig. 2, Same, of *Asclepias purpurascens* L. Fig. 3, Gynostegium of *Acerates longifolia* Ell. Fig. 4, Sketch of *Bombus scutellaris* Cress., with pollinia of Acerates longifolia. Fig. 5, Sketch of face of *Cerceris bicornuta* Guér., with pollinia of Acerates longifolia. Fig. 6, Pollinia of *Acerates viridiflora* Ell.; one in stigmatic chamber with tubes emitted. Fig. 7, Corpusculum of same, "spiked" and displaced by caudicle of inserted pollinium.

The "Curl" of Peach Leaves: a study of the abnormal structure induced by Exoascus deformans.[1]

ETTA L. KNOWLES.

(WITH PLATE XIII.)

The fungus which causes the disease of peach leaves, known as "the curl," appears very soon after the leaf unfolds. The following observations were made from alcoholic material gathered May 30, and June 8, 1887. The fungus continued to make its appearance on growing leaves up to the time of concluding this work, at the end of June, but was less abundant at that time than early in the month.

A study of the structure of the normal leaf was first made to serve as a basis of comparison with that of the diseased leaf. The drawings were all made with the camera. Fig. 1 represents a cross section of a healthy peach leaf, *a* being the upper and *b* the lower surface. The epidermis consists of a single layer of cells, the outer walls of which are covered with a very thin, delicate cuticle. The epidermal cells of the two surfaces differ considerably in shape and size, as shown in the figure. Next to the epidermal layer of the lower surface are ordinary parenchymatous cells, thin-walled, irregular in shape and arrangement, and with large intercellular spaces. Beneath the epidermis of the upper surface are from two to three layers of palisade cells, likewise thin-walled, but with smaller intercellular spaces. The cells are filled with granular protoplasm in which are round masses of chlorophyll. On the under surface are numerous stomata. Both

[1] Contributions from the Botanical Laboratory of the University of Michigan, 1887